THURSDAY, AUGUST 17, 1899.

ENZYMES.

The Soluble Ferments and Fermentation. By J. Reynolds Green, Sc.D., F.R.S. Pp. xiv+480. (Cambridge University Press, 1899.)

PROBABLY no subject in the whole of the vast domain of biology exceeds this in interest, and certainly none transcends it in the importance of its bearings on the doings of the human race. The bread and cheese we eat, the beer and wine we drink, are entirely dependent on these ferments for their preparation; and the same is true of the processes of digestion which render their products assimilable into the plant or animal economy.

Then, have not Pasteur and men who have followed him made clear that the principle of fermentation lies at the root of an enormous class of diseases; aye, and demonstrated the truth of the doctrine by that most cogent of all arguments—experimental production of the disease from the use of the agents, and cure or prevention of it by the employment of the antidotes and therapeutic measures suggested by the scientific inquiry?

The making of jams, the tinning of preserved meats and fruits, the curing of hides and tanning of leather, and a hundred other branches of industry owe their successful pursuit to the intelligent application of the teachings of science; so clearly is this being recognised now, that it is becoming customary to speak of "fermentation industries" as a class. For it must no longer be supposed that brewing is the only fermentation industry; modern discovery in connection with dyeing, the curing of tobacco, the retting of flax, and many departments of agriculture show the necessity of extending the idea. Dr. Green's aim has been to collect all that is known of the study of those remarkable and curious bodies (Enzymes) which can be extracted from the protoplasm of living cells, can be precipitated mechanically from the solutions, and preserved as dry, impalpable powders, and still retain more or less unimpaired their astonishing powers of again bringing about decompositions of sugar, fats, proteids and other organic substances in solutions just as they could in the cell itself or in the waters outside the cell.

These powers are astonishing, because they are manifested so extensively by almost unweighably small quantities of the enzyme, and because they are exerted so smoothly and with such apparent ease and economy on bodies which we know to be very stable, and which can be artificially decomposed in similar ways only by the application of very energetic processes and very wastefully.

For it would seem that the study of fermentation is now the study of enzymes. Even the one sharply contrasted case—alcoholic fermentation—which Pasteur's classical labours appeared to place in a category apart from those of the enzymes, has come into line with the rest since Buchner's discovery that an enzyme-like body can be extracted from the cells of the yeast-plant, and can split up sugar into alcohol and carbon dioxide outside the living cell.

Very few authors have attempted the collection of the huge and ever-increasing mass of information scattered through the various journals devoted to special researches on fermentations, and the student had long been dependent on the now antiquated books of Schutzenberger and Naegeli for his summary of general views on the subject, until, in 1893, the extremely interesting but meagre brochure of Bourquelot came out to tantalise him with its disappointing sketch of recent progress. Now we can claim, from the hands of an English botanist, a comprehensive survey, which, whatever its few faults in detail, covers the enormous area admirably, and brings out the salient points and recent discoveries in a very satisfactory manner.

Until a few years ago, it was generally accepted that Pasteur's doctrine—fermentation is the result of life without oxygen—formed the corner-stone of the whole subject. The gradual recognition of the important parts played by the "soluble ferments," or *enzymes*, which, though their discovery dates from 1814, 1823, 1831, were not much studied before 1870, led to the further view that two categories of fermentation-processes must be distinguished, and the attempt was made by Naegeli and Sachs to uphold the idea that soluble or "unorganised" ferments (enzymes) act differently from "organised" or living ferments—*e.g.* bacteria, yeast-cells, &c.

Apart from other discrepancies, the fact that fermentations occur universally in higher plants and animals, as well as in lower organisms, rendered this view untenable, until the startling discovery by Buchner, in 1897 that a something of the nature of an enzyme can be extracted in water from the yeast-cell, which—outside the yeast-cell and quite independent of it—converts sugar into carbon dioxide and alcohol, may be said to have removed its last prop.

Although Lafar, in his remarkably able summary of the ferment-activity of the lower organisms, restricts the definition of fermentation to "transformations of matter . . . exclusively by the vital action of ferments," understanding by the latter word the living cells themselves, it is evident that we are here confronted with an entirely different definition of fermentation. Having abandoned successively the views that it is a phenomenon of life without oxygen, that it is confined to the protoplasmic activity of lower organisms, that there are two different categories of ferments—organised and unorganised, we are now threatened once more with the generalisation that fermentation is a purely chemical phenomenon due to the peculiar molecular activity of certain bodies formed, it is true, by protoplasm, but acting independently of it: a generalisation supported by Fischer's work on the constitution of the sugars, which he regards as so built up that an enzyme can only attack any particular sugar the molecular symmetry of which is related to its own, much as the wards of a lock can be overcome only by a key with a particular pattern.

Dr. Green gives us a very exhaustive account of the many various enzymes now known, classifying them under the following heads.

(1) Those which transform insoluble carbohydrates, producing soluble sugars—*e.g. Diastase* in germinating seeds and other plant-organs, which attacks starch;

Inulase, which decomposes inulin ; *Cytase*, which hydrolyses cellulose.

(2) Those which transform more complex sugars into simpler compounds of the same class—*e.g. Invertase*, which attacks cane-sugar ; *Glucase*, which splits up maltose, and others.

(3) Those which break up glucosides into some sugar and an aromatic body—*e.g. Emulsin*, which decomposes the amygdalin of almonds into sugar and prussic acid ; *Myrosin*, which breaks up the sinigrin of mustard into a sugar and the pungent substance so well known.

(4) Proteolytic enzymes, such as *Pepsin* and *Trypsin*, which decompose insoluble and indigestible proteids into soluble and digestible peptones and other bodies, and play so important a part in digestive processes generally.

(5) The clotting enzymes which bring about coagulations—*e.g. Rennet*, so important in converting milk into cheese ; *Thrombase*, the enzyme concerned in the coagulation of blood ; *Pectase*, the chief agent in forming vegetable jellies.

(6) The *Lipases*, concerned in decomposing oils and fats.

(7) The *Oxydases*, a curious class of enzymes recently shown to be active in carrying oxygen and bringing about the oxidation of certain vegetable juices—*e.g. Laccase*, concerned in the formation of lacquer varnish.

(8) A number of enzymes as yet unclassified—*e.g. Urease*, which induces the formation of ammonium carbonate from urea, and the newly discovered "zymase" of Buchner—the alcohol producing enzyme.

It is, of course, impossible in a review to go far into particulars concerning these numerous forms, of which, moreover, there are many varieties. On reading Dr. Green's admirable and exhaustive account of them, the student will be struck with the prominent position which the study of plants occupies in the elucidation of the properties of enzymes. It has been far too fashionable in this country to regard enzymes and the study of fermentation as if they were in some way specially accredited to the domain of the chemist, whereas inasmuch as any such specialisation can be insisted upon, the study is far more within the domain of the botanist and the physiologist, a fact very clearly brought out in this book ; as are also many of the important bearings of the study on the numerous applications of botanical science in the arts.

Secondly, it is worth remarking, in full view of the industrious and valuable work done by able continental botanists and physiologists, how conspicuous are the researches of English investigators in this department of science during the last few years, denoting a phase of activity on the part of our physiologists and botanists which promises well in the future. The author has collected a long list of authorities, and since he has made the study of fermentations peculiarly his own for some years, we may accept the literature as practically complete. At the same time, in view of the remarks on p. 75, we should have expected some quotation of Mr. Parkin's recent and important paper on the inulins in monocotyledons.

In view of the modernity of the study of enzymes, we can hardly be surprised at the lack of any complete deductive explanation of their action, though one of the most interesting sections of the book is that discussing the various hypotheses raised. Our ignorance of the constitution of enzymes no doubt stands at the bottom of this, and it is not at present clear what is meant by a soluble enzyme or by solution. But the fatal blocks to progress in the study of their constitution so far have been their instability during separation, and the uncertainty as to their purity ; consequently the analyses so far attempted cannot be relied on, and we do not even know of any enzyme that it is proteid in nature. All we can be sure of is that a given watery extract washes out from living protoplasm a something—which we term an enzyme—which is capable of converting enormous masses of some other body—*e.g.* sugar—and can itself be mechanically precipitated, re-dissolved and so on. This precipitate may even be dried and retain its specific powers on re-solution. Whether the precipitate consists principally of the enzyme itself or of some body or bodies to which it is attached, is an unsolved question.

But when active and in solution, it is significant that the properties of an enzyme can be destroyed in a few moments by raising the temperature beyond a (relatively low) maximum, and that the activity rises and falls with a scale of temperature between the limits ; on the other hand, it differs from a living organism in being capable of exerting its specific power in presence of an antiseptic.

In the discussion regarding fermentation as a chemical process, these facts should not be overlooked, and it is as true to-day as it was in Pasteur's time, that you cannot have fermentation without life.

No matter how "dead" an enzyme may be ; no matter whether its remarkable energy consists in surface-actions or in vibrations propagated through the solution, in temporary chemical unions and disunions or in electrical hydrolysis ; and no matter what its chemical analyses may imply as to its proteid nature—the fact must be maintained that enzymes are built up by living protoplasm, and normally exert their best actions in connection with the living cell. In many respects, indeed, they suggest essential bits of the protoplasm, and in many ways remind us that we have not yet done with the physiological or "vital" theory of fermentation, and this will, we think, strike most readers, though perhaps Dr. Green's summing up inclines more to the view that fermentation is a purely chemical process. Not the least important prop to the chemical theory of enzyme-action is furnished by Croft Hill's recent work on the action of maltase or glucase on malt-sugar, and his remarkable discovery that a reversal of the enzyme-action may occur, reminding us of the reversals occurring in certain chemical processes.

Here, however, we must stop. It is not necessary to recommend the perusal of the book to all interested in the subject, since it is indispensable to them, and we will merely conclude by congratulating the Cambridge Press on having added to their admirable series of Natural Science Manuals an eminently successful work on so important and difficult a theme, and the author on having written a treatise cleverly conceived, industriously and ably worked out, and, on the whole, well written. At the same time, it should be pointed out that such a work was especially in need of a good and exhaustive index, and that it is a pity the author did not compile one himself.

CALCULATION BY ABACUS.

Traité de Nomographie. Par Maurice d'Ocagne. Pp. xiv + 480. (Paris: Gauthier-Villars, 1899.)

THIS is a book which ought to make even the ordinary reader appreciate the perennial freshness of mathematics. The method of "Nomography" (X3 of the international catalogue), recent as it is in its more important developments, is based upon a very simple idea which has long been familiar—that of the indexed scale. The ever-recurring problem of applied mathematics is to calculate an unknown numerical quantity from its relation to other quantities that are known. The simplest case is when two quantities x, y are connected by a relation $f(x, y) = 0$ or $y = \phi(x)$. For practical purposes it is convenient to have a permanent record of a large number of corresponding values of x and y so that for any given value of x the approximate value of y may be at once found or obtained by simple interpolation. Three methods are available: the first is that of a numerical table, such as a table of logarithms; the second that of the graph, for instance the curve $f(x, y) = 0$ or $y = \phi(x)$ referred to rectangular coordinates; the third is that of the indexed scale, that is to say a straight line or curve at different points of which the corresponding values of x and y are shown in figures. A familiar example is given by a thermometer with Centigrade and Fahrenheit readings, or by a measuring tape with centimetres marked along one edge and inches along the other.

In this very simple case the advantage of the indexed scale is not very obvious; even here, however, the method combines much of the vividness of the graph with a considerable saving of space. It is when three or more variables are connected by a relation that the great value of the scale method becomes apparent. Suppose, for instance, we have a relation

$$F\{\phi(x), \chi(y), \psi(z), \omega(t)\} = 0$$

where x, y, z, t are the variables and F, ϕ, χ, ψ, ω are known functions. The essence of the nomographic function consists in first plotting off in a suitable way indexed scales of $\phi(x)$, $\chi(y)$, $\psi(z)$, $\omega(t)$, and then employing a linkage or similar mechanism to associate four corresponding values, x' y', z', t'. In the case of two variables x, y the "linkage" consists merely in the juxtaposition of the scales; when a proportion sum is done with a slide-rule, the scales are moved relatively to each other; in most of M. d'Ocagne's illustrations, involving several variables, the scales are either superposed in a two-dimensional grating or a movable linkage is used consisting of a transparent sheet with lines of reference ruled upon it, or a combination of both devices is employed.

Of course a method so elastic leaves ample room for ingenuity in constructing an "abacus," as M. d'Ocagne calls it, suited to any particular problem. The author gives an abundant variety of illustrations, many of great practical importance to the physicist and engineer: it is by studying these, and actually taking readings for himself, that the reader will succeed in appreciating the value of the method. For of this, as of other graphical methods, it may be said that merely reading it up, or understanding its principles in a general way, is of little use as compared with a thorough working knowledge of its application.

At the same time, M. d'Ocagne has done really good service in devoting his final chapter to the general theory. This has, in its way, the same kind of special value as Reuleaux's "Kinematics of Machinery" in relation to the ordinary treatises on mechanism. For in this chapter we have a clear conspectus of the general principles which underlie the construction of *any* abacus; and, what is still more remarkable, all possible varieties of abacus are classified into perfectly definite types which can be expressed by a simple abstract notation. Oddly enough, the enumeration of the different types leads to a difficult problem in the partition of numbers, happily solved by Major MacMahon.

It is not impossible that the human race may ultimately set off against the ravages of warfare the indirect stimulus which it has given to mathematics; nomography, at any rate, has been developed in great measure to meet the demands of civil and military engineering. M. d'Ocagne's numerous bibliographical notes will enable his readers to follow in detail, if they wish, the history of the subject. Pure and applied mathematicians alike will be grateful to him for a work so full of novelty and interest; while its subject-matter, as well as its clearness and simplicity, ought to make it eminently acceptable to the engineer.

G. B. M.

OUR BOOK SHELF.

Die Spiele der Menschen. By Karl Groos. Pp. vi + 538. (Jena: G. Fischer, 1899.)

PROF. GROOS will add by the present volume to the reputation he has already earned by his well-known work on the "Games of Animals." A really comprehensive account, at once sympathetic and intelligent, of the games of both children and adults has long been a desideratum with the psychologist as well as with the anthropologist, and Prof. Groos's new work goes very far indeed towards permanently supplying the want. As is only right and proper, by far the larger part of the book is given up to an exhaustive description of the facts as far as they are known; the "Theory of Play" enunciated in the second part of the treatise can thus be judged by the reader upon a sufficiently wide basis of empirical information. The range and the accuracy of Prof. Groos's knowledge are alike surprising; not only is he a mine of information about the amusements of his own country, but he appears, for instance, as much at home in the English nursery and playground as though he had been brought up amongst us. Almost the only signs of imperfect knowledge of English games to be detected in the whole book are the author's ascription of "Hare and Hounds," in its familiar form, exclusively to America, and his apparent ignorance of the continued vitality of "Hunt the Slipper." As a psychologist Prof. Groos is distinguished by a singular subtlety of discrimination; his account, for instance, of the various elements which enter into the gambler's enjoyment of high play, or, again